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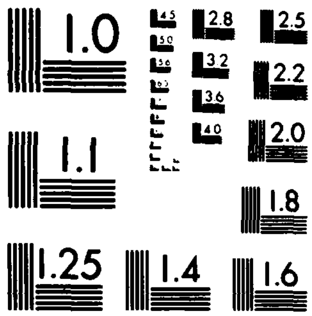

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FOREIGN TECHNOLOGY DIVISION

CURRENT DENSITY IN CATHODE SPOTS IN THE CONDENSED DISCHARGE

by

Emil Zizka

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

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CURRENT DENSITY IN CATHODE SPOTS IN THE CONDENSED DISCHARGE.

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Is measured current density in the cathode spots of the condensed discharge by the method of time sweep of the traces of discharge on the rotating electrode. Is determined the relative dependence of current density in the cathode spot on the material of electrode and on a change in the current.

Introduction.

To the study of process on the surface of electrodes is paid considerable attention as a result of its importance during the explanation of the mechanism of discharge. One of the values being investigated in the condensed discharges and the steady-state arc discharges is current density on both electrodes, especially on the cathode. Its connection/communication with the mechanism of ionization was explained to many authors. In the condensed discharge where the value of flowing current is changed in the flow of discharge, reaching 10^3 A even more, it is important to know time dependence of the value of current density on the electrodes and conditions for splitting/fission of channel in the space of electrodes. This problem is studied in our work.

METHOD OF MEASUREMENT.

In view of the possibility of obtaining the new data about staining on the electrodes, although under the special conditions for measuring the current density, was used the method of time sweep of the trace of discharge on the rotating electrode. The first experiments in this direction were performed earlier [1].

Principal part of the equipment is the rotating electrode which serves simultaneously as the cathode and the anode (Fig. 1). Electrode - this is the metal foil, stuck on the disk from the dural. At a distance of 3 mm from the surface of rotating electrode are stably fastened/strengthened external iron electrodes (anode A, roller K).

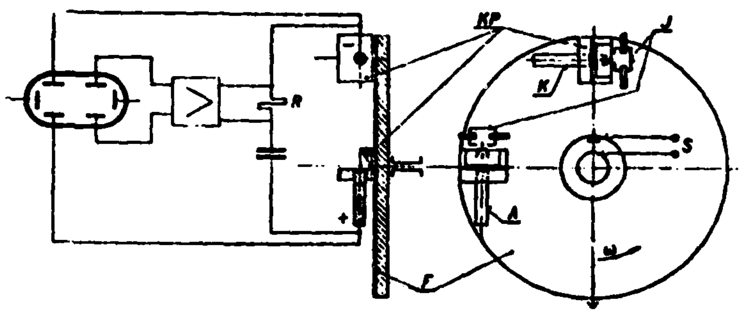

Fig. 1. Schematic of equipment.

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In order to direct the expansion of the discharge in the direction perpendicular to the linear velocity and to restrict the width of discharge column, and thereby also the surface area of rotating electrode, were applied the radial slots of a sufficient length, formed in the ceramic partition/baffle KP, placed at a distance of 0.2 mm from the surface of foil. Since in the measurements were applied the discharges of low voltage, then for the ignition of discharge we used spraying/dusting/deposition of plasma from auxiliary discharge gap/interval J [2]. Position of traces on the electrodes provided the rotary contact S, placed in the trigger circuit of the igniting device/equipment. With the linear velocity of electrode from the foil - 130 m/s in the middle of slot - and to the width of slot was limited the maximum time of the duration of separate cathode spots at the specific place for the surface of electrode by several μs.

This provides the determination of the total area P of cathode spots at any moment of discharge with the acceptable error. The course of current and voltage/stress was removed/taken oscillographically. Value P changed continuously, as can be seen from Fig. 2 it was determined in eight or sixteen the intervals into which was divided the discharge time.

Current density was established/installed from the instantaneous value of current J, area P and time t, assuming, that the real area of cathode spot was identical and with the area of the corresponding trace on the surface of the cathode, isolated with the width of slot. The following error in the measurement appeared as a result of the limitation of discharge column near the cathode by slot, which caused an increase in the current density. By this were introduced into the calculation of systematic errors which did not make it possible to determine absolute values. Therefore by this method were determined some relative dependences of current density which have qualitative character.

For checking the method relative to the values of the measured current densities was investigated the dependence of current density on the cathode from aluminum on the different width of slot. Measurements were made in the condensed discharge with the aperiodic course of the current whose maximum value oscillated about 2000 A. Time of the discharge time 142-156 μs, slot 0.2, 0.6, 0.9, 1.1, 1.5, 2.0 mm. Then was investigated the value of current density on the cathode in the dependence on the material of electrode. Measurements were made on Ni, Cu, Zn, Cd, Sn and Pb in the condensed discharge with aperiodic course of current with two maximums. Time of discharge time 196 μs, the width of slot the constant of 0.6 mm. This form of pulse of current was utilized for determining the dependence of current density on a change in the current. The surface of the electrodes being investigated for the certainty directly before the measurements by identical method was mechanically polished, it was cleaned of oxide and other impurities. The maximum depth of primes varied about 2 μ.

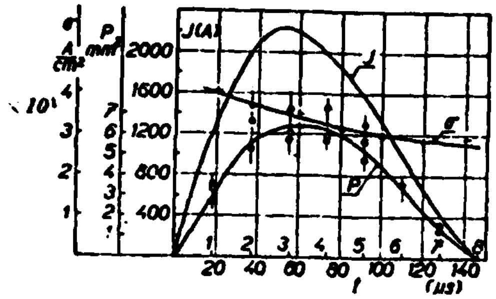

Fig. 2. Course of the current density σ, current I and area of trace P depending on time (width of slot 0.60 mm).

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RESULTS OF MEASUREMENTS.

Current density in both cases varied in the interval of order 10^4A/cm² and in the process of discharge changed. In the discharge with the aperiodic course of current with one maximum it gave in the process of the discharge to 30-50% of value, measured in 20 μs discharge. The incidence/drop was developed in all slots of different width (Fig. 3). Mean value was raised with the decrease of the width of slot. Discharge in this case burned at the highest current density on the cathode, although the discharge column had the capability of expansion along the slot. An increase in the current density on the cathode during the use of narrower slots can be explained as follows [4]. The limitation of discharge column by slot in the space of cathode as a result of the large losses in this space raises the voltage gradient, necessary for the ionization and thereby is raised the current density in the column, which then affects current density on the cathode.

In the discharge with the course of current with two maximums was discovered in its first part to the minimum of the current of the incidence/drop in the current density, similarly as in simple impulse/momentum/pulse. With the second increase in the current the current density began again to increase and it approximately follows the course of current (Fig. 5). The values of separate measurements are designated for Zn and Ni. As can be seen from Figs. 4 and 5 repeat current density, furthermore, also the course of voltage/stress. Therefore it is possible to say the following. If through the discharge column after the incidence/drop in the current flows/occurs/lasts under the effect of the external constants of the discharge circuit again high current, then this is connected with the increasing formation of new carriers. This, however, as a result of the inertia of the process of ionization it occurs more lately, only after the specific increase in the voltage on spark discharger. An increase in the voltage gradient leads to an increase in the current density in the discharge column, thereby also in the cathode compartment of discharge. A change of the current density in the cathode compartment is developed also in the value of current density on the cathode.

The average/mean value of current density depends on the material of electrode (Fig. 5); however, it cannot be given independently depending on certain physical constant of the material of electrode. In form of traces and different disturbances of surface by discharge in the different metals it is possible to judge sufficiently great jet effect, which protrude from the electrode, on its value. In this case the current density was higher on the metals which have in the traces after discharge the large destruction of surface, i.e., in Zn and Sn. In these metals is developed also the larger scatter of the measured values of current density, than in the metals, in which is absent deep destruction of surface in the traces, i.e., Ni and Cu.

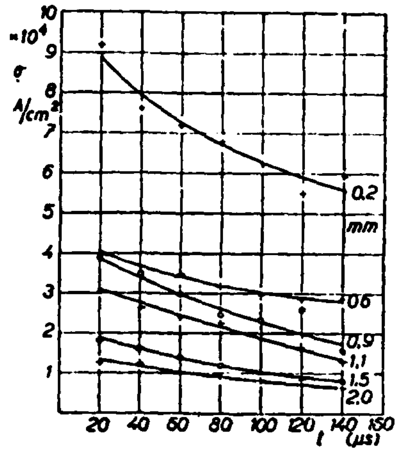

Fig. 3. Dependence of current density on the cathode on the width of slot in the condensed discharge with the aperiodic course of current.

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At the value of current density had considerable effect roughness and the finish of the surface of electrode, their heterogeneity led to the scatter of the measured values. The presence of admixtures/impurities, for example oxide, it conducted to an increase in the current density. Traces in this case were clearly limited. On the contrary, on the surface of that thinly cleaned without the admixtures/impurities cathode traces were not at all noticeable and when the maximum of current reached 2000 A. On this phenomenon already mention in their work the authors of works [3], which measured the current density in the cathode spots on the different metals in arc from 2.5 A to 10 A. Traces, as can be seen from Fig. 6, greatly separated and they increased in the direction of the surface inequalities of material and when these inequalities were perpendicular to relative motion of rotating electrode. In the case of aluminum (Fig. 6) separation of traces is larger than in electrodes without the oxide film and admixtures/impurities (Figs. 4 and 7). This is caused by the nonuniform removal of oxide layer by discharge. As can be seen from Fig. 7, the form of traces is characteristic for each metal. Their value affects the material of electrode and inequality and the surface finish. From a number of traces it follows that on the rough surface was formed a larger number of simultaneously burning spots, than on the surface of that purified. On the contaminated surface of electrode burned a smaller number of spots, than on the surface of pure/clean.

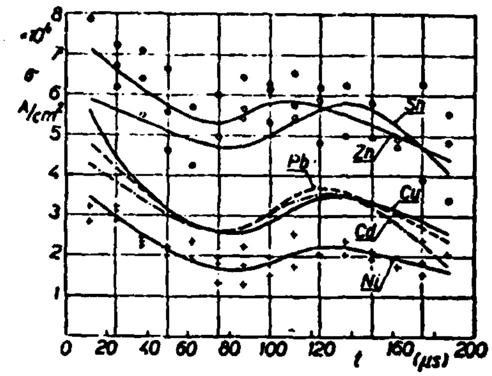

Fig. 5. Course of current density on the cathode in the condensed discharge with the aperiodic course of current with two maximums to Sn, Zn, Cd, Pb, Cu, Ni.

CONCLUSION.

Experimental results can be generalized into the following:

Current density in the cathode spot of the condensed discharge depends on the material of electrode. Its value oscillates in the interval of order 10^4A/cm^2. With the increase of current on the preceding/previous incidence/drop the current density in the cathode spots is raised. The limitation of discharge column in the cathode compartment and the jets of metals, which protrude from the surface of electrode, cause also an increase in the current density in the cathode spot. A number of spots simultaneously of those burning increases with the growing current and, furthermore, it is determined by roughness of the surface of electrode. The layer of admixtures/impurities, for example oxide, decreases a number of spots.